

## Over-Voltage Protection Load Switch with Surge Protection

### Features

- Wide Input Voltage range from 3.1V to 28V
- 5.5A continuous current capability
- Input maximum voltage rating: 29V<sub>DC</sub>
- Integrated ultra-low Ron switch: typical 20mΩ
- Adjustable Over-Voltage Lockout (OVLO)
- Fast Over-Voltage Protection turn-off response: typical 50ns
- Surge Protection compliant with IEC61000-4-5 up to ±100V
- Input system ESD protection
  - IEC 61000-4-2 Contact discharge: ±8kV
  - IEC 61000-4-2 Air gap discharge: ±15kV
- Reverse-Current Protection (RCP)
- Over-Temperature Protection (OTP)
- Under-Voltage Lockout (UVLO)
- WLCSP 2.54mm×1.49mm×0.555mm-15B, 0.5mm pitch package

### Applications

- Smartphones
- Tablets
- Charging Ports

### General Description

The AW32105 is a high input voltage, large current and ultra-low Ron load switch bidirectional blocking.

The AW32105 is turned off very fast once the input voltage exceeds the OVP threshold to prevent damage to the protected downstream devices. The IN pin is capable of withstanding fault voltages to 29V<sub>DC</sub>. The AW32105 provides a default OVP threshold of 23V typical, and the OVP threshold can be adjusted from 4V to 24V through external OVLO pin.

The AW32105 has all time Reverse Current Protection regardless of the ENB logic level. Once the voltage on OUT is higher than IN for RCP trigger voltage, the RCP circuit disables the power switch. Two AW32105 chips can be used in parallel to support dual power inputs connecting to the same charging circuit.

The AW32105 OVP load switch features surge protection, an internal clamp circuit protects the device from surge voltages up to +/-100V. It also features over-temperature protection that prevents itself from thermal damaging.

### Typical Application Circuit

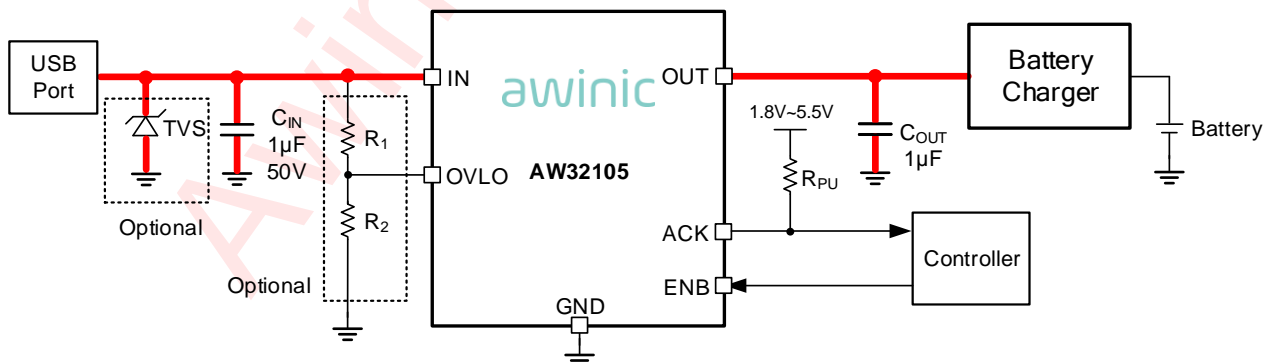


Figure 1 AW32105 Typical Application Circuit

R<sub>1</sub> and R<sub>2</sub> are used for OVP threshold adjustment, to use default OVP threshold, connect OVLO to ground.

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## Pin Configuration and Top Mark

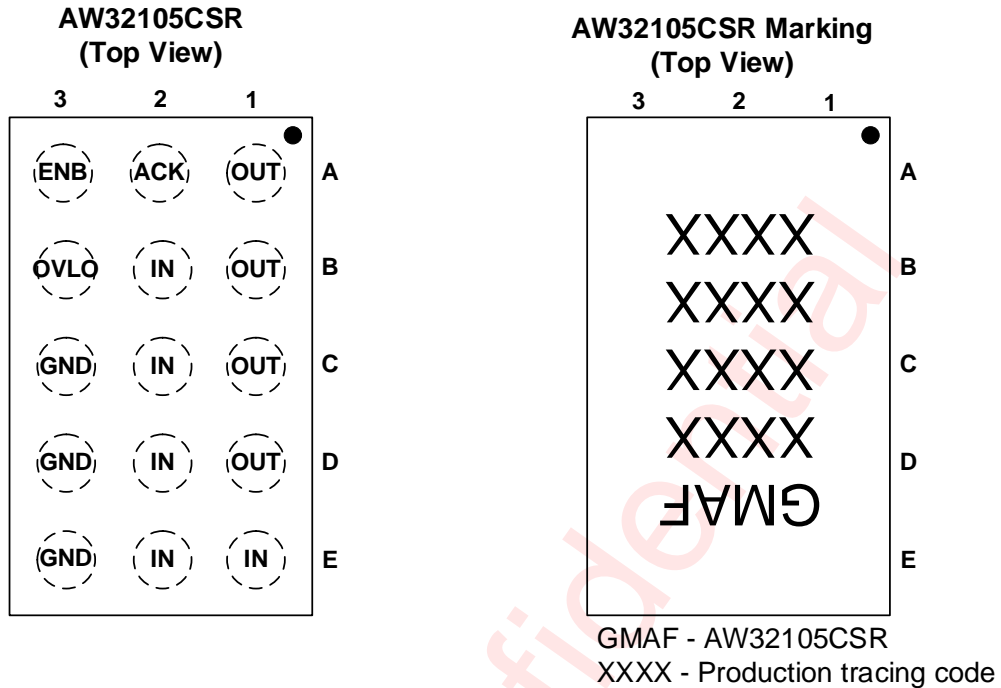


Figure 2 Pin Configuration and Top Mark

## Pin Definition

Pin	Name	Description
A1, B1, C1, D1	OUT	Switch output
E1, B2, C2, D2, E2	IN	Switch input and device power supply
A2	ACK	Power good flag, active-low, open-drain output. When $V_{IN\_UVLO} < V_{IN} < V_{IN\_OVLO}$ , ACK is pulled low, otherwise it's hi-Z state
A3	ENB	Enable pin, active low
B3	OVLO	OVP threshold adjustment pin
C3, D3, E3	GND	Device ground

## Functional Block Diagram

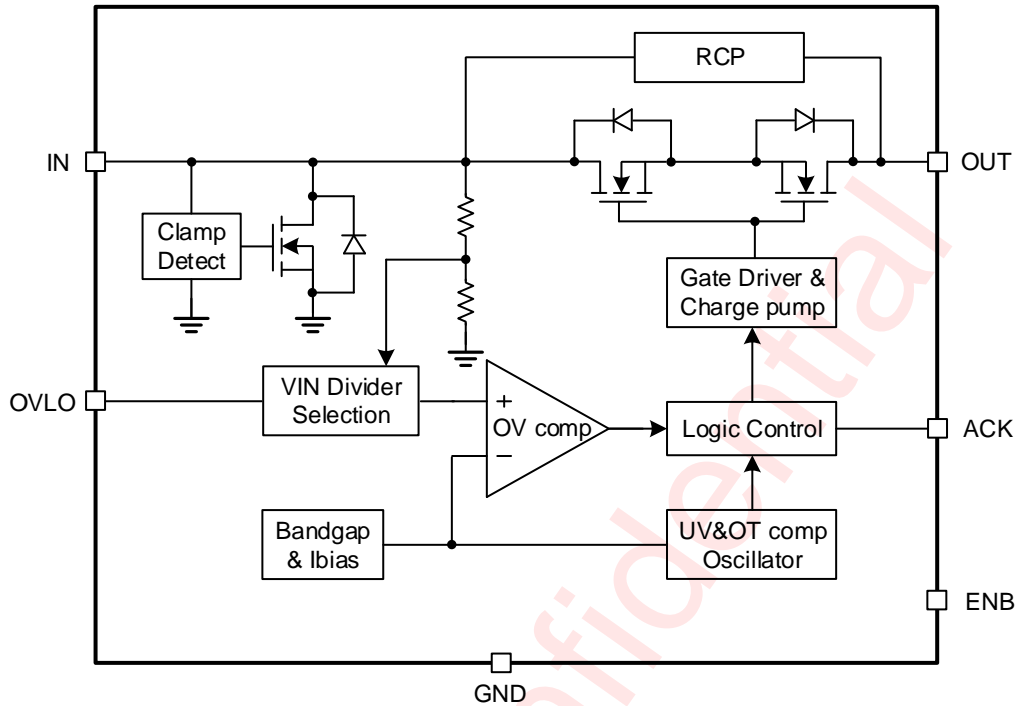


Figure 3 Functional Block Diagram

## Typical Application Circuits

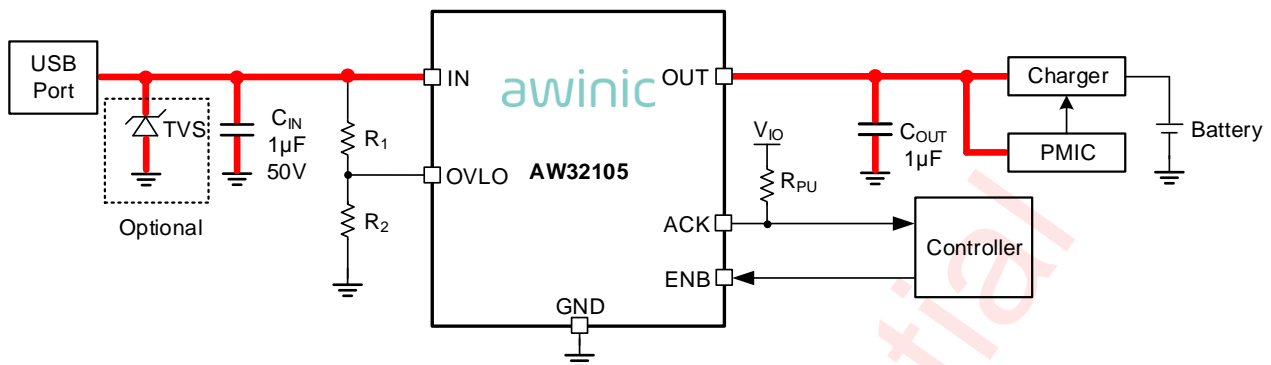


Figure 4 AW32105 application with one charging input

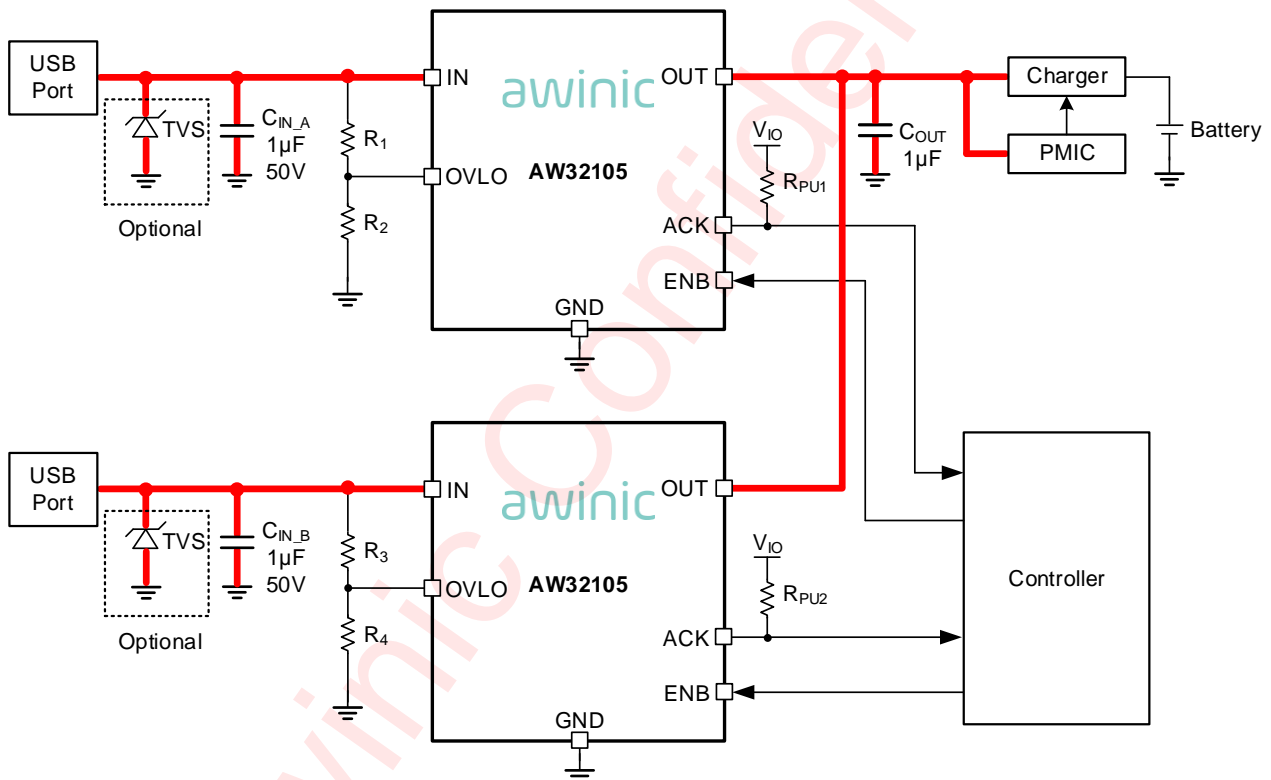


Figure 5 AW32105 application with two charging inputs

### Notice for Typical Application Circuits:

1. If VBUS is required to pass surge voltage greater than 100V, external TVS is needed, the maximum clamping voltage of the TVS should be below 30V.
2. When the default OVP threshold is used, connect OVLO pin to GND directly or through a 0Ω resistor. **OVLO pin cannot be left floating.**
3. If R<sub>1</sub> R<sub>2</sub>, R<sub>3</sub> and R<sub>4</sub> are used to adjust the OVP threshold, it is better to use 1% precision resistors to improve the OVP threshold precision.
4. If ACK is not used, it can be left floating, or short to GND.

5.  $C_{IN} = 1\mu F$  is recommended for typical application, larger  $C_{IN}$  is also acceptable. The rated voltage of  $C_{IN}$  should be larger than the TVS maximum clamping voltage, if no TVS is applied and only AW32105 is used, the rated voltage of  $C_{IN}$  should be 50V.
6.  $C_{OUT}$  minimum is recommended to be  $1\mu F$ . The rated voltage of  $C_{OUT}$  should be larger than the OVP threshold. For example, if the OVP threshold is 23V, the rated voltage of  $C_{OUT}$  should be 50V.

## Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW32105CSR	-40°C ~ 85°C	WLCSP 2.54mm×1.49mm ×0.555mm -15B	GMAF	MSL1	ROHS+HF	9000 units/ Tape and Reel

## Absolute Maximum Ratings <sup>(NOTE 1)</sup>

PARAMETERS		RANGE
Supply voltage range IN		-0.3V to 29V
Input voltage range	OVLO, ENB	-0.3V to 29V
Output voltage range	OUT	-0.3V to 27V
	ACK	-0.3V to 6V
Continuous current of switch IN-OUT <sup>(NOTE2)</sup>		5.5A
Peak switch current on IN and OUT pin(10ms) <sup>(NOTE2)</sup>		8A
Junction-to-ambient thermal resistance $\theta_{JA}$		72°C/W
Maximum operating junction temperature $T_{JMAX}$		150°C
Operating free-air temperature range		-40°C to 85°C
Storage temperature $T_{STG}$		-65°C to 150°C
Lead temperature (soldering 10 seconds)		260°C
ESD		
Human Body Model (All pins, per ESDA/JEDEC JS-001-2017)		±2kV
Charged Device Model (All pins, per ESDA/JEDEC-JS-002-2018)		±1.5kV
IEC61000-4-2 system ESD on IN pin with 1μF $C_{IN}$	Contact discharge	±8kV
	Air gap discharge	±15kV
Latch-Up		
Test condition: JESD78E		±200mA
Surge		
IEC61000-4-5 test with 2Ω equivalent series resistance		±100V

**NOTE1:** Conditions out of those ranges listed in “absolute maximum ratings” may cause permanent damages to the device. In spite of the limits above, functional operation conditions of the device should within the ranges listed in “recommended operating conditions”. Exposure to absolute-maximum-rated conditions for prolonged periods may affect device reliability.

**NOTE2:** Limited by thermal design.

## Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_{IN}$	Input DC voltage	3.1		28	V
$V_{OVLO\_RNG}$	OVP threshold adjustable range	4		24	V
$C_{IN}$	Input capacitance		1	100	μF
$C_{OUT}$	Output load capacitance		1	100	μF

## Electrical Characteristics

$V_{IN}=5V$ ,  $V_{ENB}=0V$ ,  $C_{IN}=1\mu F$ ,  $C_{OUT}=1\mu F$ ,  $T_A = 25^\circ C$  for typical values (unless otherwise noted).

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
$V_{IN\_CLAMP}$	Input clamp voltage	$I_{IN} = 10mA$	30	32.2		V
$R_{ON}$	On resistance	$V_{IN} = 5V$ , $I_{OUT} = 1A$ , see Figure 6		20	30	m $\Omega$
$I_Q$	IN on-state quiescent current	$V_{IN} = 5V$ , $V_{OVLO} = 0V$ , $I_{OUT} = 0A$		96	140	$\mu A$
		$V_{IN} = 20V$ , $V_{OVLO} = 0V$ , $I_{OUT} = 0A$		193	260	$\mu A$
$I_{SD}$	IN on-state quiescent current	$V_{ENB} = 5V$ , $V_{IN} = 5V$ , $I_{OUT} = 0A$		13	25	$\mu A$
		$V_{ENB} = 5V$ , $V_{IN} = 20V$ , $I_{OUT} = 0A$		39	60	$\mu A$
$I_{LEAK\_IN}$	IN off-state leakage current	$V_{ENB} = 5V$ , $V_{IN} = 5V$ , $V_{OUT} = 0V$		13	25	$\mu A$
		$V_{ENB} = 5V$ , $V_{IN} = 20V$ , $V_{OUT} = 0V$		39	60	$\mu A$
$I_{LEAK\_OUT}$	OUT off-state leakage current	$V_{ENB} = 5V$ , $V_{OUT} = 5V$ , $V_{IN} = 0V$		2.2	8	$\mu A$
		$V_{ENB} = 5V$ , $V_{OUT} = 20V$ , $V_{IN} = 0V$		25	45	$\mu A$
$I_{LEAK\_RCP}$	RCP leakage current	$V_{ENB} = 0V$ , $V_{OUT} = 5V$ , $V_{IN} = 0V$		2.2	8	$\mu A$
$I_{IN\_OVLO}$	Input current at over-voltage condition	$V_{IN} = 5V$ , $V_{OVLO} = 3V$ , $V_{OUT} = 0V$		90	140	$\mu A$
$V_{OVLO\_TH}$	OVLO set threshold		1.15	1.20	1.25	V
$V_{OVLO\_SEL}$	External OVLO select threshold	OVLO rising	0.19	0.26	0.33	V
		Hysteresis		0.06		V
$I_{LEAK\_OVLO}$	OVLO pin leakage current	$V_{OVLO} = V_{OVLO\_TH}$	-0.2		0.2	$\mu A$
<b>Protection</b>						
$V_{IN\_OVLO}$	OVP trip level	$V_{IN}$ rising	22.5	23	23.5	V
		Hysteresis		0.45		V
$V_{IN\_UVLO}$	UVLO trip level	$V_{IN}$ rising		2.95	3.08	V
		Hysteresis		0.1		V
$V_{trig}$	RCP trigger voltage	$V_{trig} = V_{OUT} - V_{IN}$	15	35	55	mV
$T_{SDN}$	Shutdown temperature			150		$^\circ C$
$T_{SDN\_HYS}$	Shutdown temperature hysteresis			20		$^\circ C$

**Electrical Characteristics (Continued)**

$V_{IN}=5V$ ,  $C_{IN}=1\mu F$ ,  $C_{OUT}=1\mu F$ ,  $T_A = 25^\circ C$  for typical values (unless otherwise noted).

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Units
<b>Digital Logical Interface</b>						
$V_{OL}$	ACK output low voltage	$I_{SINK} = 6mA$			0.5	V
$I_{LEAK\_ACK}$	ACK leakage current	$V_{IO} = 5V$ , ACK de-asserted	-0.5		0.5	$\mu A$
$V_{IH}$	ENB input high voltage		0.8			V
$V_{IL}$	ENB input low voltage				0.4	V
$I_{LEAK\_ENB}$	ENB leakage current	$V_{ENB} = 5V$ , $V_{IN} = 0V$			1	$\mu A$
$R_{ENB}$	ENB pull-down resistance	$V_{ENB} = 2V$ , $V_{IN} = 5V$		1		$M\Omega$
<b>Timing Characteristics (see Figure 7 and Figure 8)</b>						
$t_{en}$	Enable Time	From ENB to $V_{OUT} = 10\%$ of $V_{IN}$ ; (Including 15ms debounce time); $V_{IN} = 5V$ ; $C_{OUT} = 100\mu F$ ; $R_{LOAD} = 100\Omega$		16		ms
$t_{TLH}$	VOUT rise time	$V_{OUT}$ from 10% to 90% $V_{IN}$ ; $C_{OUT} = 100\mu F$ ; $R_{LOAD} = 100\Omega$	$V_{IN} = 5V$	2.5		ms
			$V_{IN} = 20V$	2		ms
$t_{OFF\_OVP}$	The delay time between $V_{IN}$ over voltage and switch turn-off	$C_{OUT} = 1\mu F$ , $R_L = 100\Omega$ , $OVLO = GND$ , $V_{IN} > V_{IN\_OVLO}$ to $V_{OUT}$ stop rising, $V_{IN}$ initial 20V, 85V surge test, $T_A = 25^\circ C$		50		ns
$t_{degl}$	RCP de-glitch time	From $V_{OUT} > V_{IN} + 35mV$ to switch off		3.6		ms
$t_{dis(RCP)}$	RCP turn off time	From $V_{OUT} > V_{IN} + 88mV$ to switch off		10		$\mu s$
$t_{ON}$	turn-on time	ENB to $V_{OUT} = 90\%$ $V_{IN}$ ; $C_{OUT} = 100\mu F$ ; $R_{LOAD} = 100\Omega$	$V_{IN} = 5V$	19		ms
			$V_{IN} = 20V$	17		ms
$t_{START}$	Start-up time	ENB to ACK low; $C_{OUT} = 100\mu F$ ; $R_{LOAD} = 100\Omega$		30		ms
$t_{OFF}$	turn-off time	ENB to $V_{OUT} = 10\%$ $V_{IN}$ ; $C_{OUT} = 100\mu F$ ; $R_{LOAD} = 100\Omega$	$V_{IN} = 5V$	23		ms
			$V_{IN} = 20V$	23		ms

## Waveforms and Test Circuits

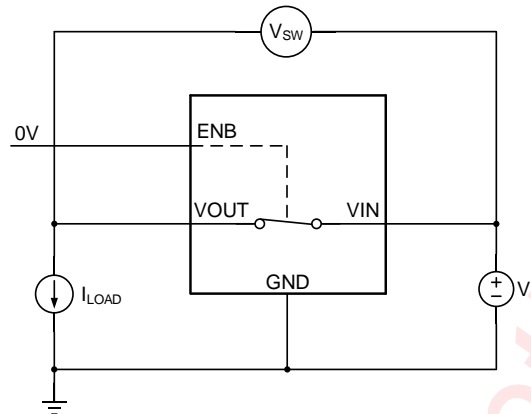


Figure 6 On resistance Measurement Test Circuit

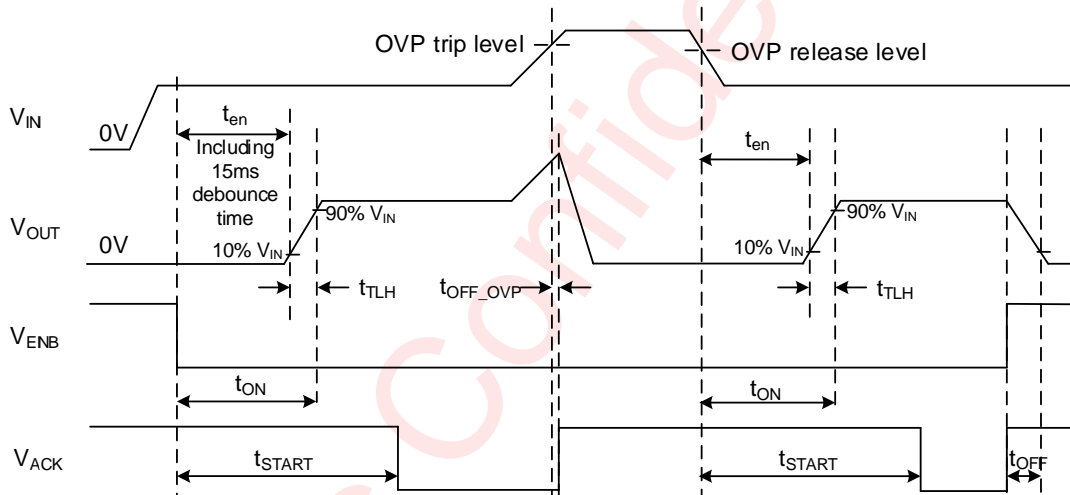
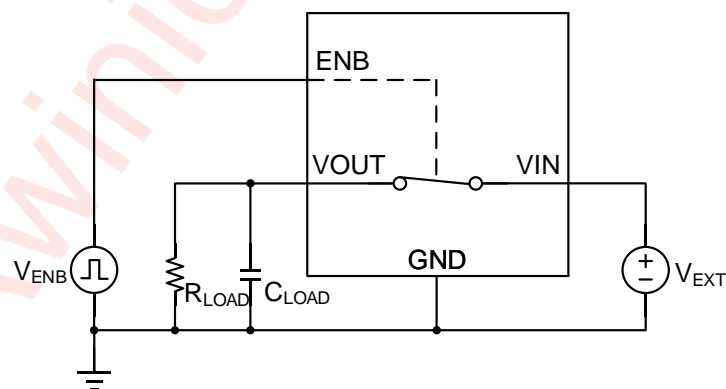


Figure 7 Operating Waveforms and Timing Definitions



Test condition are  $V_{IN}=3.1V$  to  $20V$ ,  $C_{LOAD}=100\mu F$ ,  $R_{LOAD}=100\Omega$ , where:

$R_{LOAD}$ =Load resistance.

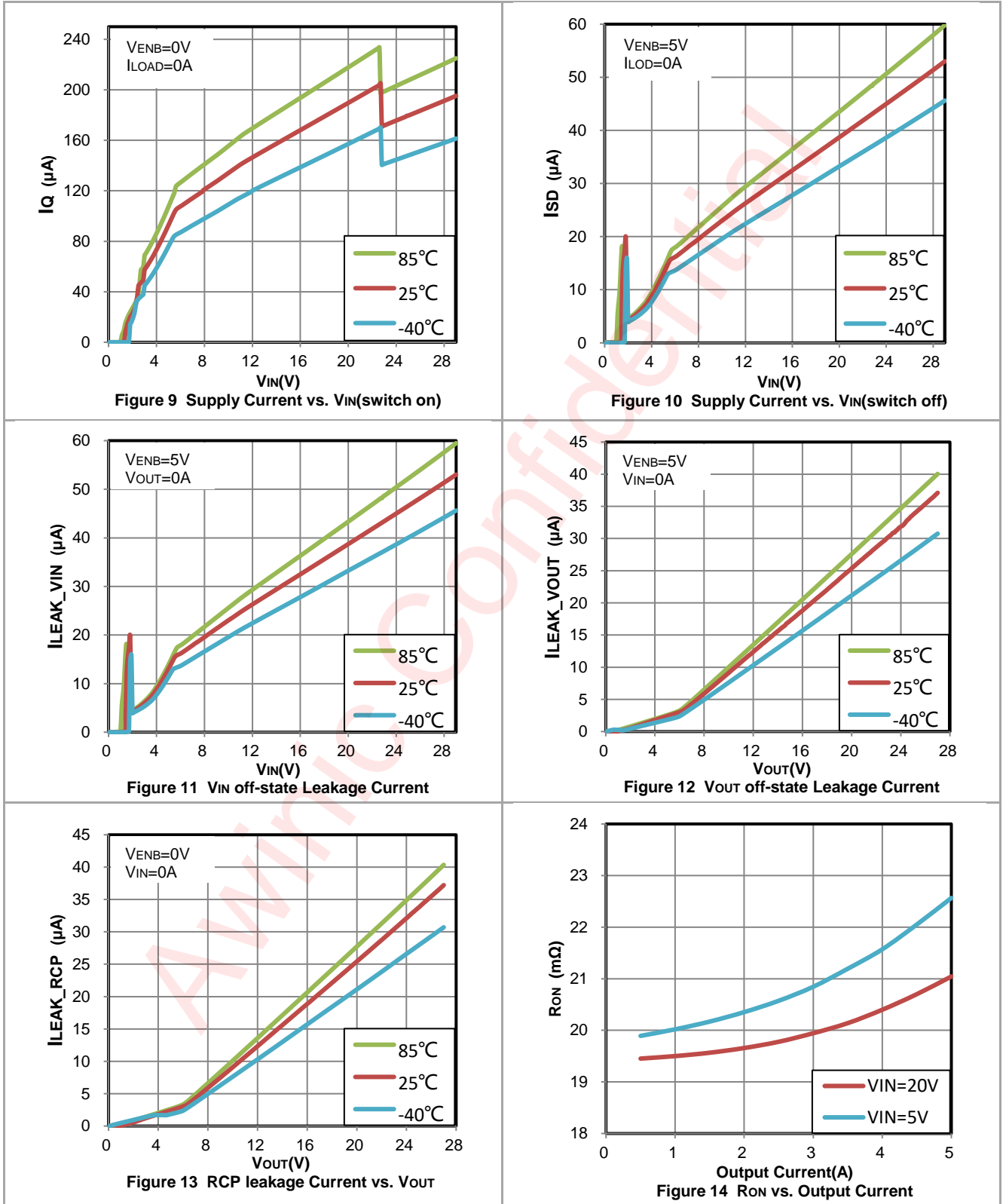
$C_{LOAD}$ =Load capacitance.

$V_{EXT}$ =External voltage source applied to VIN pin for measurements.

Figure 8 Waveform and Timing Measurements Test Circuit

## Typical Characteristics

Ambient temperature is 25°C,  $V_{IN} = 5V$ ,  $V_{ENB} = 0V$ ,  $V_{OVLO} = 0V$ ,  $C_{IN} = C_{OUT} = 1\mu F$ , unless otherwise noted.



## Typical Characteristics (Continued-1)

Ambient temperature is 25°C,  $V_{IN}=5V$ ,  $V_{ENB}=0V$ ,  $V_{OVLO}=0V$ ,  $C_{IN}=C_{OUT}=1\mu F$ , unless otherwise noted.

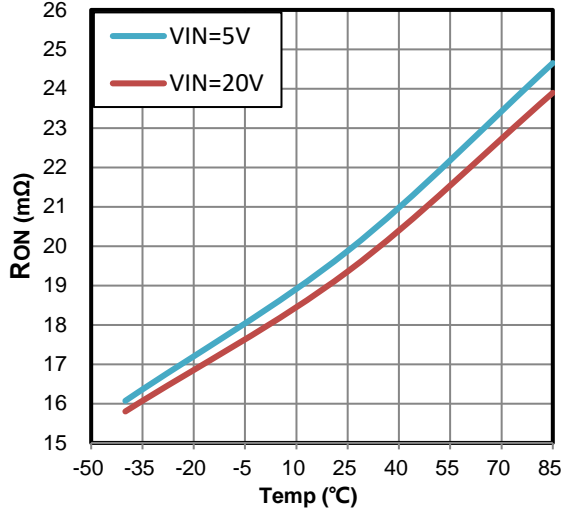


Figure 15 Ron vs. Temperature

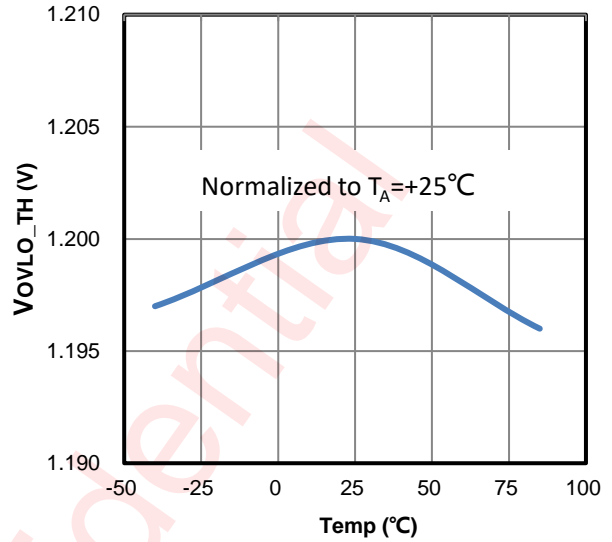


Figure 16 OVLO set threshold vs. Temperature

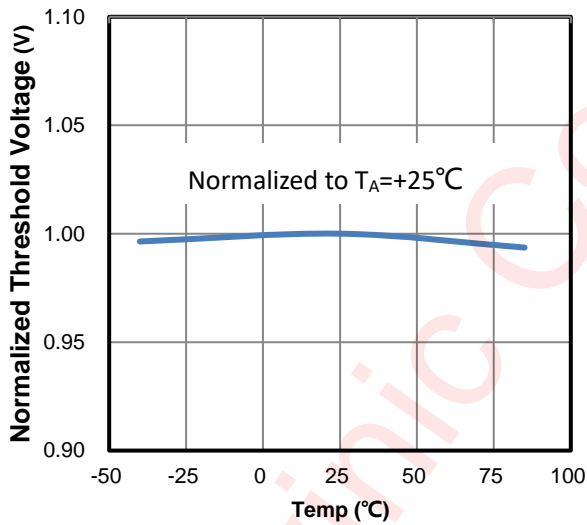


Figure 17 OVP threshold vs. Temperature

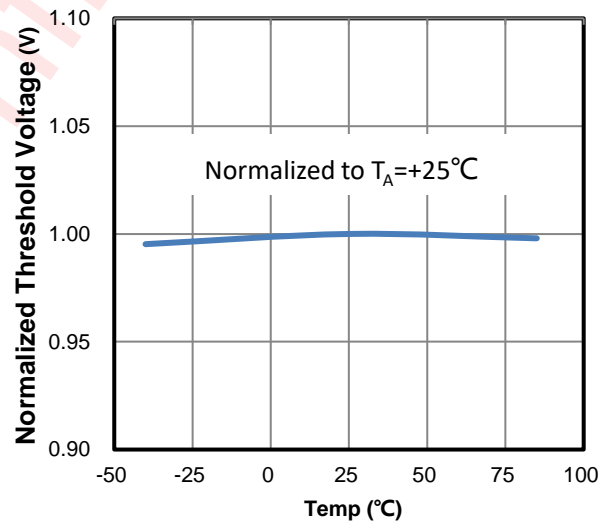


Figure 18 UVLO threshold vs. Temperature

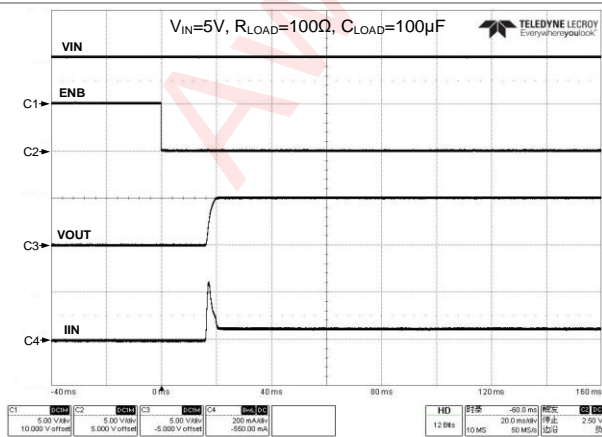


Figure 19 Turn-On Time and Inrush Current at 5V

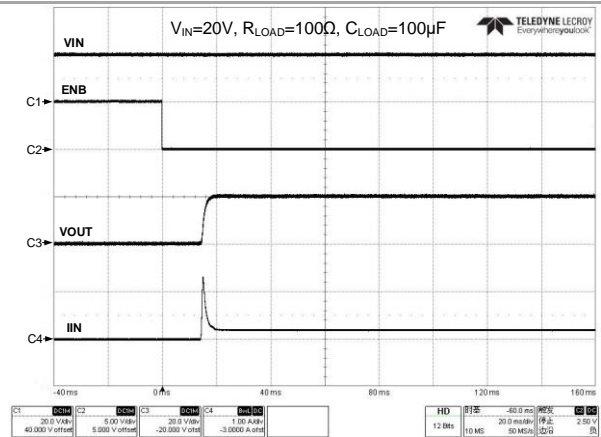
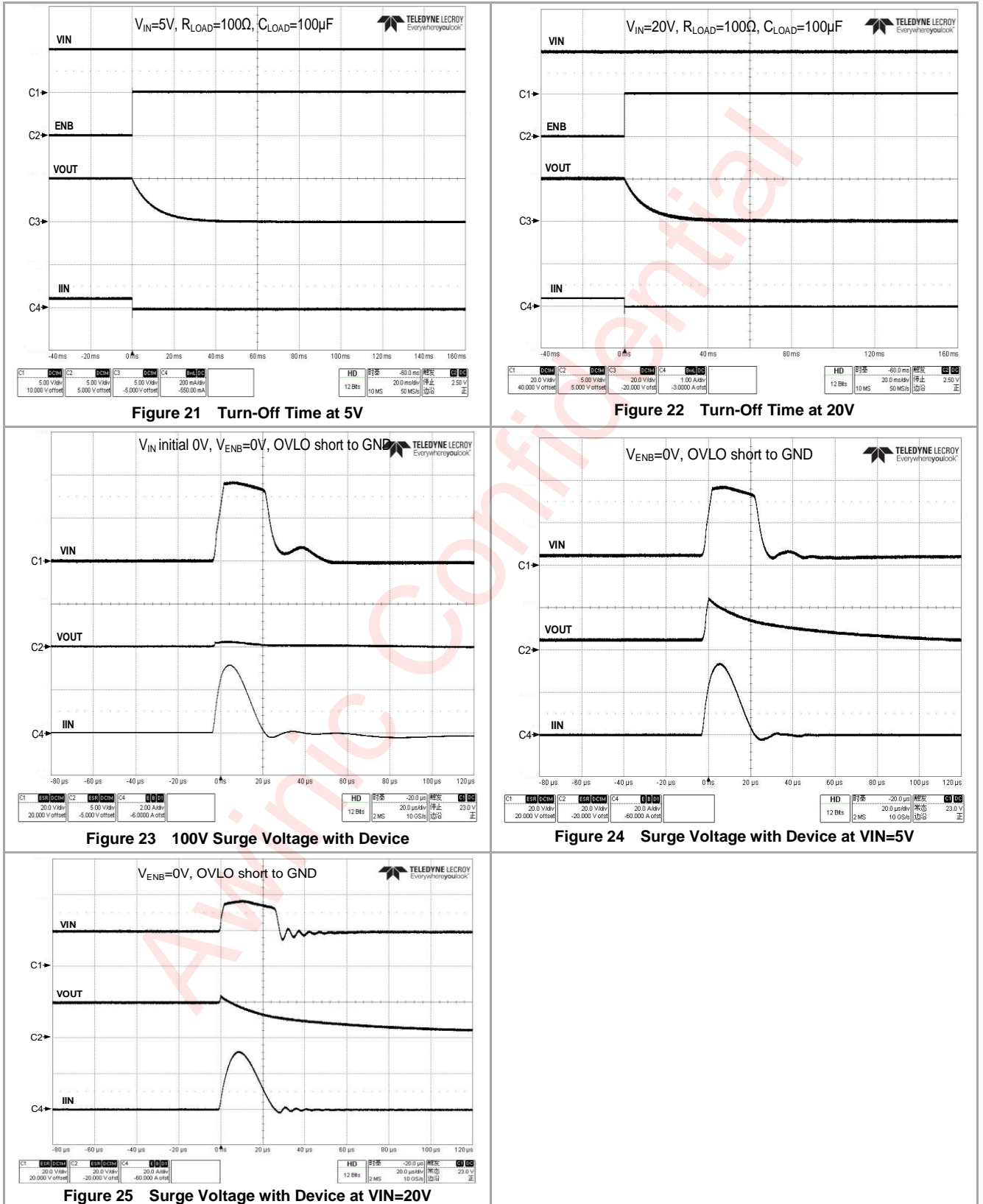


Figure 20 Turn-On Time and Inrush Current at 20V

## Typical Characteristics (Continued-2)

Ambient temperature is 25°C,  $V_{IN}=5V$ ,  $V_{ENB}=0V$ ,  $V_{OVLO}=0V$ ,  $C_{IN}=C_{OUT}=1\mu F$ , unless otherwise noted.



## Functional Description

### Device Operation

If the AW32105 is enabled and the input voltage is between UVLO and OVP threshold, the internal charge pump begins to work after debounce time, the gate of the nFET switch will be slowly charged high till the switch is fully on. ACK will be driven low about 30ms after VIN valid, indicating the switch is on with a good power input. If the input voltage exceeds the OVP trip level, the switch will be turned off in about 50ns. If ENB is pulled high, or input voltage falls below UVLO threshold, or over-temperature happens, the switch will also be turned off.

Table1. AW32105 Function and Logic Table

ENB	VIN	VOUT	ACK	Operation Mode
L	<V <sub>IN_UVLO</sub>	X	Hi-Z	Under-voltage lockout, switch open. (UVLO fault)
L	V <sub>IN_UVLO</sub> <V <sub>IN</sub> <V <sub>IN_OVLO</sub>	X	L	Enabled, switch closed, charging path on. (Normal on)
L	X	X	Hi-Z	Over-temperature protection, switch open. (OTP fault)
L	>V <sub>IN_OVLO</sub>	X	Hi-Z	Over-voltage lockout, switch open. (OVP or OVLO fault)
H	X	X	Hi-Z	Disable, switch open. (Normal off)
X	X	V <sub>OUT</sub> >V <sub>IN</sub>	Hi-Z	Reverse current protection, switch open. (RCP fault)

Note: H=logic high level, L=logic low level, Hi-Z=high-impedance(off-state), X= don't care.

### Surge Protection

The AW32105 integrates a clamp circuit to suppress input surge voltage. For surge voltages between V<sub>IN\_OVLO</sub> and V<sub>IN\_CLAMP</sub>, the switch will be turned off but the clamp circuit will not work. For surge voltages greater than V<sub>IN\_CLAMP</sub>, the internal clamp circuit will detect surge voltage level and discharge the surge energy to ground. The device can suppress surge voltages up to 100V.

### Over-Voltage Protection

If the input voltage exceeds the OVP rising trip level, the switch will be turned off in about 50ns. The switch will remain off until V<sub>IN</sub> falls below the OVP falling trip level.

### OVP Threshold Adjustment

If the default OVP threshold is used, OVLO pin must be grounded. If OVLO pin is not grounded, and by connecting external resistor divider to OVLO pin as shown in the typical application circuit, between IN and GND, the OVP threshold can be adjusted as following:

$$V_{IN\_OVLO} = \frac{R_1+R_2}{R_2} V_{OVLO\_TH}$$

For example, if we select R<sub>1</sub> = 1MΩ and R<sub>2</sub> = 100kΩ, then the new OVP threshold calculated from the above formula is 13.2V. The OVP threshold adjustment range is from 4V to 24V. When the OVLO pin voltage V<sub>OVLO</sub> exceeds V<sub>OVLO\_SEL</sub> (0.26V typical), V<sub>OVLO</sub> is compared with the reference voltage V<sub>OVLO\_TH</sub> (1.2V typical) to judge whether input supply is over-voltage.

### ACK Output

The device features an open-drain output ACK, it should be connected to the system I/O rail through a pull-up

resistor. If the device is enabled and  $V_{IN\_UVLO} < V_{IN} < V_{IN\_OVLO}$ , ACK will be driven low indicating the switch is on with a good power input. If OVP, UVLO, or OT occurs, or ENB is pulled high, the switch will be turned off and ACK will be pulled high. The pull up resistor value is recommended to be 10KΩ to 200KΩ.

### Reverse Current Protection

AW32105 has all time reverse current protection regardless of the ENB logic level. Once the voltage on  $V_{OUT}$  is higher than  $V_{IN}$  for 35mV, the RCP circuit is triggered after a 3.6ms de-glitch time. If the voltage gap is greater than 88mV, RCP triggers disables the power switch.

During the startup deglitch time, if the device detects the  $V_{OUT}$  voltage is higher than  $V_{IN}$  by 35mV, the power switch does not turn on.

The RCP circuit helps by providing the capability of parallel connection of two USB charging ports to a single charger input, without backward leakage.

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## Application Information

### Capacitors Selection

$C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 1\mu\text{F}$  is recommended for typical application, larger  $C_{IN}$ ,  $C_{OUT}$  is also acceptable.

The rated voltage of  $C_{IN}$  should be larger than the TVS maximum clamping voltage, if no TVS is applied and only AW32105 is used, the rated voltage of  $C_{IN}$  should be 50V. The rated voltage of  $C_{OUT}$  should be larger than the OVP threshold. For example, if the OVP threshold is 23V, the rated voltage of  $C_{OUT}$  should be 35V or higher.

The recommended value of capacitors and boundary values can refer to the following table:

Capacitor	Typical Value ( $\mu\text{F}$ )	Boundary Value ( $\mu\text{F}$ )
$C_{IN}$	1	0.1~100
$C_{OUT}$	1	0.1~100

### Resistors Selection

The default OVLO voltage is 23V, when using default OVP threshold, it is recommended to connect OVLO to ground or through 0 $\Omega$  resistor. When  $R_1$  and  $R_2$  are used to adjust the OVP threshold, it is better to use 1% precision resistors to improve the OVP threshold precision. When  $(R_1+R_2)$  is larger, the clamping voltage of OUT is smaller. It is recommended to select  $R_1 = 1\text{M}\Omega$ ,  $R_2$  can calculate the value according to the required OVP threshold. The calculation formula is as follows: the typical value of  $V_{OVLO\_TH}$  is 1.2V, and the adjustable range of  $V_{IN\_OVLO}$  is 4V ~ 24V.

$$V_{IN\_OVLO} = \frac{R_1+R_2}{R_2} V_{OVLO\_TH}$$

The recommended value of resistors and boundary values can refer to the following table:

Resistor	Typical Value ( $\Omega$ )	Boundary Value ( $\Omega$ )
$R_1$	1M	1K~10M
$R_2$	100K	Determined by $R_1$

### TVS (if used)

First of all, the working voltage of TVS should be determined. TVS with  $V_{RWM} \geq 10\text{V}$  can be selected for 5V charging port, TVS with  $V_{RWM} \geq 12\text{V}$  can be selected for 9V charging port, and TVS with  $V_{RWM} \geq 24\text{V}$  can be selected for 20V charging port. Secondly, it is necessary to meet the requirement of surge protection capability. Assuming that the customer wants to select a TVS with a voltage of 300V, the TVS should meet the requirement of  $I_{PP} \geq 300\text{V} / 2\Omega = 150\text{A}$ . When selecting the model of external TVS, the maximum clamping voltage of the TVS should be below **30V**. Too high clamping voltage of TVS will cause damage to OVP chip.

## PCB Layout Consideration

To make fully use of the performance of AW32105, the guidelines below should be followed.

1. All the peripherals should be placed as close to the device as possible. Place the input capacitor  $C_{IN}$  on the top layer (same layer as the AW32105) and close to IN pin, and place the output capacitor  $C_{OUT}$  on the top layer (same layer as the AW32105) and close to OUT pin.
2. If external TVS is used, IN pin routing passes through the external TVS firstly, and then connect AW32105.
3. Red bold paths on figure 4 and 5 are power lines that will flow large current, please route them on PCB as straight, wide and short as possible.
4. If  $R_1$  and  $R_2$  are used, route OVLO line on PCB as short as possible to reduce parasitic capacitance.
5. The power trace from USB connector to AW32105 may suffer from ESD event, keep other traces away from it to minimize possible EMI and ESD coupling.
6. Use rounded corners on the power trace from USB connector to AW32105 to decrease EMI coupling.

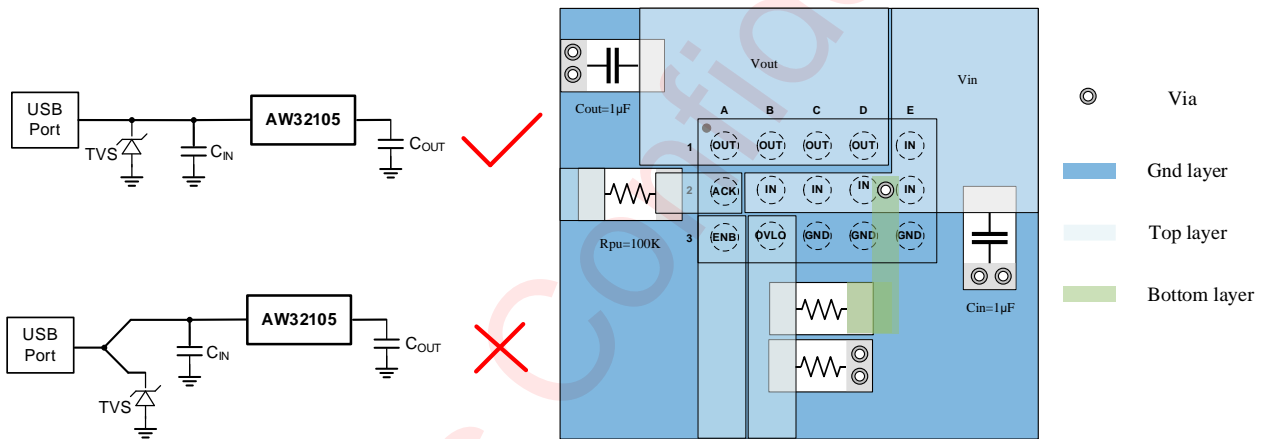
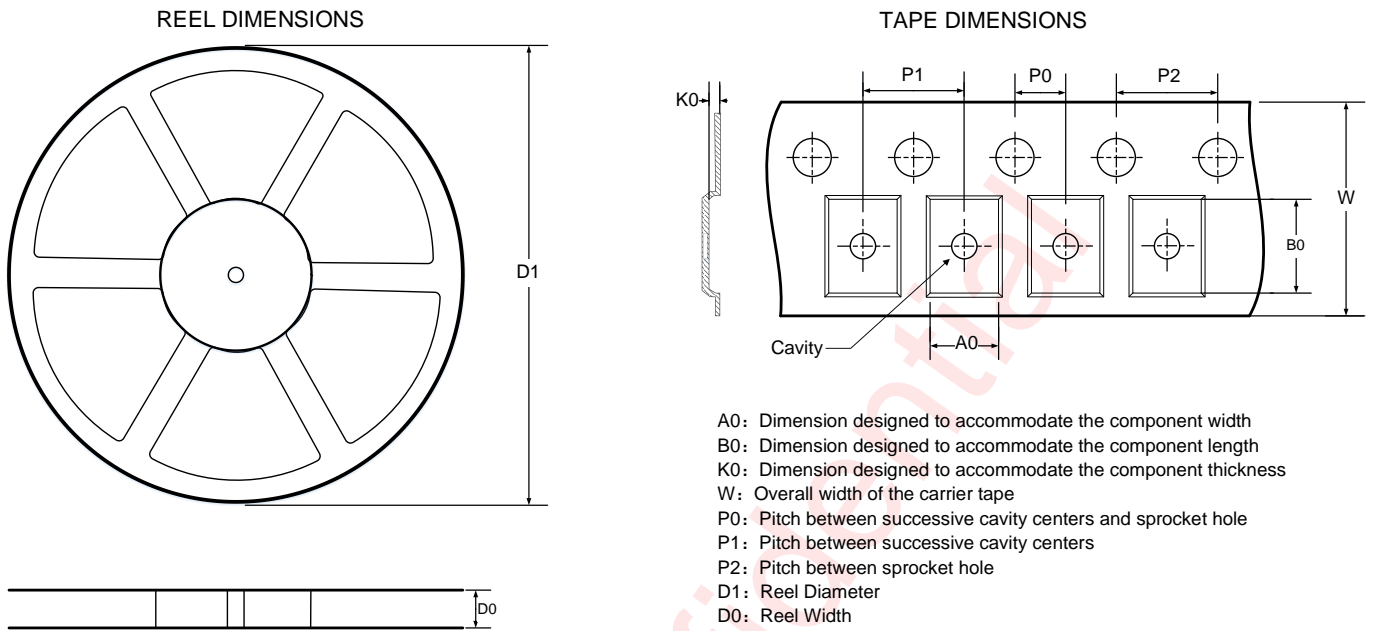
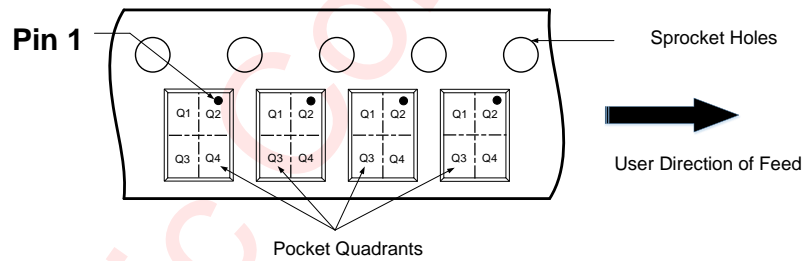


Figure 26 External Components Placements and PCB Layout Example

## Tape and Reel Information



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



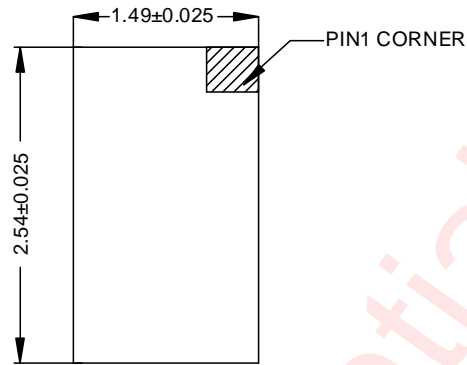
Note: The above picture is for reference only. Please refer to the value in the table below for the actual size

### DIMENSIONS AND PIN1 ORIENTATION

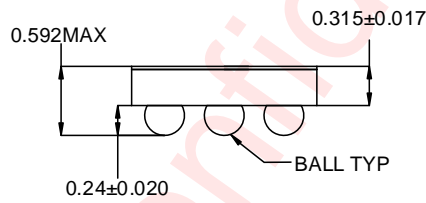
D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
330	12.5	1.7	2.72	0.72	2	4	4	12	Q2

All dimensions are nominal

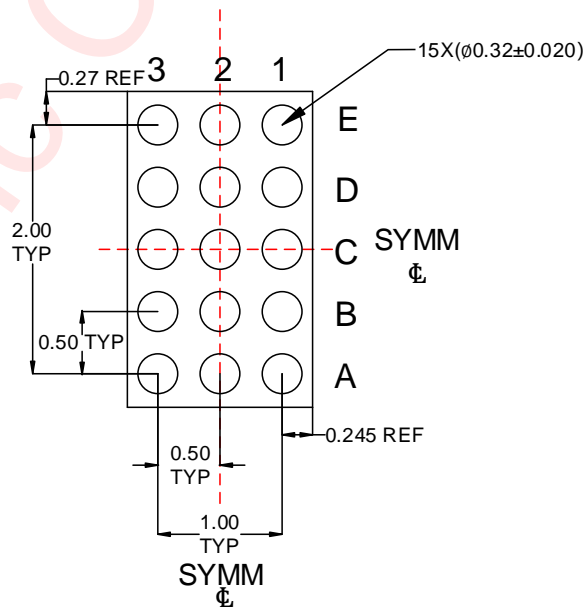
## Package Description



Top View



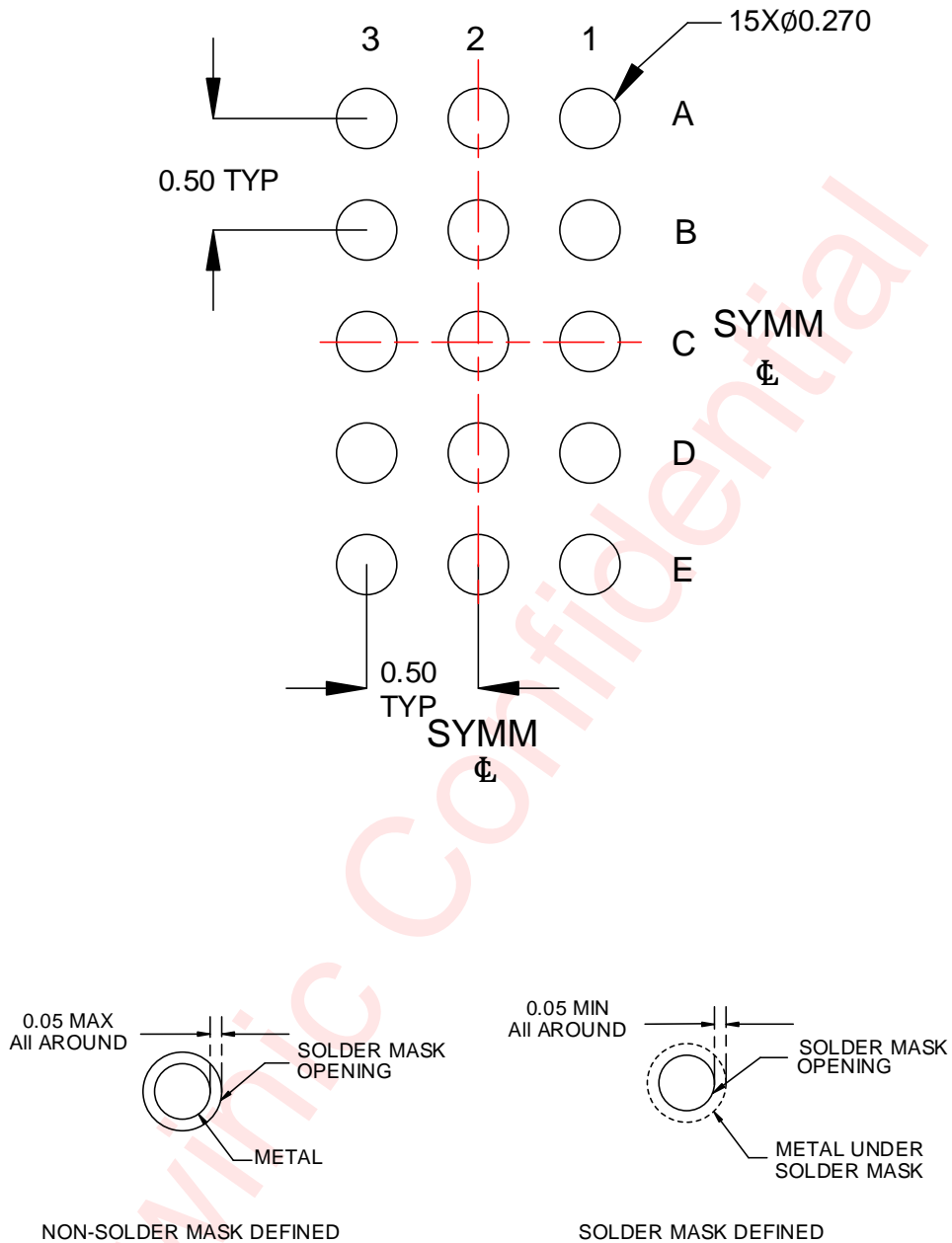
Side View



Bottom View

Unit:mm

Land Pattern Data



Unit: mm

## Revision History

Version	Date	Change Record
V1.0	Jan. 2022	Datasheet V1.0 released.
V1.1	Jul. 2024	Added air gap discharge ESD capability.
V1.2	Mar. 2025	Changed the continuous current capability from 5A to 5.5A.

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